are known to the mathematicians, or as they occur in Mr. Spencer's "Formula." Of course a single line would suffice, if the differential calculus were employed.

Take the very simplest case, a stone of mass M, and weight W, let fall. After it has fallen through a height h, and has thus acquired a velocity v, the Conservation of Energy gives the relation

$$M\frac{v^2}{2} = Wh.$$

Here both sides express *real things*; $M\frac{v^2}{2}$ is the kinetic energy acquired, Wh the work expended in producing it.

But if we choose to divide both sides of the equation by $\frac{v}{2}$ (the average velocity during the fall) we have (by a perfectly legitimate operation)

$$Mv = Wt,$$

where t is the time of falling. This is read:—*the momentum acquired is the product of the force into the time during which it has acted.* Here, although the equation is strictly correct, it is an equation between purely artificial or non-physical quantities, each as unreal as is the product of a quart into an acre. It is often mathematically convenient, but that is all. The introduction of these artificial quantities is, at least largely, due to the strong (but wholly misleading) testimony of the "muscular" sense.

Each of these modes of expressing the same truth, of course gives its own mode of measuring (and therefore of defining) force.

The second form of the equation gives

$$W = \frac{Mv}{t}.$$

Here, therefore, force appears as the time-rate at which momentum changes; or, if we please, as the time-rate at which momentum is produced by the force. In using this latter phrase we adopt the convenient, and perfectly unmisleading, anthropomorphism of the mathematicians. This is the gist of a part of Newton's second Law.

The first form of the equation gives

$$W = \frac{M\frac{v^2}{2}}{h},$$

so that the same force now appears as the space-rate at which kinetic energy changes; or, if we please, as the space-rate at which energy is produced by the force.

Here are some of Mr. Spencer's comments:—"force is that which changes the state of a body; force is a rate, and a rate is a relation (as between time and distance, interest and capital); therefore a relation changes the state of a body."

The contradiction which Mr. Spencer detects here, and over which he waxes eloquent and defiant, exists in his own mind only. The anthropomorphism which has misled him is but a convenient and harmless relic of the old erroneous interpretations of the impressions of sense.

P. G. TAIT

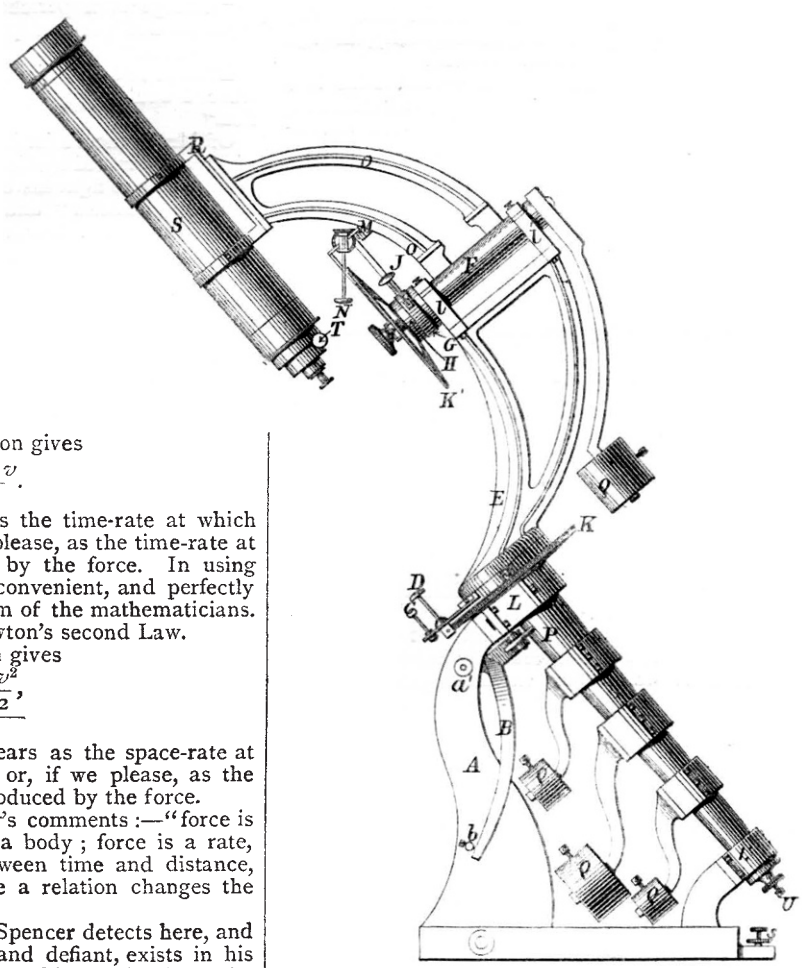
COMET-FINDERS

IT is only lately that the meteorites, or many of them which we see of a night making bright streaks in the heavens, have been shown to belong to definite streams having definite orbits and periods, and with the increase of our knowledge of these orbits the number of comets identified as travelling in the same orbits as meteor-streams has likewise advanced.

Now that the intimate relation between comets and meteorites has been settled, greater interest attaches to the discovery of these casual visitors, many of which have passed in our neighbourhood unobserved. This is shown by the increased number of comets seen, now that it is part of the business of several observatories to keep up a systematic search.

To do this properly, a telescope of large field of view is required, and a constant sweeping of the heavens must be kept up, and to do this with an ordinary equatorial is extremely tedious, owing to the continual change of the position of the body required.

To go back to early days of comet-finding, we call to mind the first instrument specially constructed for the purpose, so far as we are aware. It is a telescope of Galilean construction, with an object-glass of 2½ inches



diameter, and having a total length of 5 inches. This was made by Dollond during the first few years of this century for Dr. Kitchener. Since that time astronomical instruments have grown apace, and we have now before us Dr. Carl's "Repertorium für Experimental-Physik" containing a description of the new comet-finder constructed by Herr Schneider for the Observatory at Vienna.

The telescope of this instrument has an object-glass of

6 inches aperture and 4½ feet focal length, and the mounting is a striking change from what we are usually accustomed to see. The great point to be attained by it is to carry the telescope equatorially and allow it to move on a declination axis in such a manner that the eye-end remains stationary while sweeping the heavens. It will be seen from the plate which, by the kindness of Dr. Carl, we are able to reproduce, that the declination axis is carried above the polar axis somewhat in the usual way, but that the telescope, instead of being carried by its middle at the end of the declination axis, is carried by a frame, O, so that the eyepiece is in the prolongation of that axis, and also in the prolongation of the polar axis, so that it remains stationary, while the object-glass sweeps in all directions. The handles D and N, within easy reach of the observer, enable him to give the requisite motion to the telescope without the change of position necessary with an ordinary instrument. The telescope is balanced on the declination axis F by the counter-weight Q, and the excess of weight on one side of the polar axis is balanced by the counter-weights Q Q Q.

Herr Schneider proposes to mount telescopes of much greater size, say 30 or 40 feet long, in the same manner.

NOTES

M. MILNE-EDWARDS having completed the publication of his great work on "Physiologie Comparée," a subscription has been opened by M. Dumas, the Perpetual Secretary of the Academy of Sciences, for the purpose of presenting the veteran zoologist with a gold medal. Subscriptions are to be sent to M. Maindron at the Secretariat of the Academy of Sciences, or to M. Victor Masson, publisher, Boulevard St. Germain, Paris. M. Milne-Edwards's great work is composed of fourteen large octavo volumes—the first four of which are out of print—of 500 pages each; the publication began in 1857, and has been accomplished by twenty-three years of continual work. It includes all the lectures which have been delivered by M. Milne-Edwards at the Museum of Natural History during that lengthened period, and could not have been accomplished if the author had not had the advantage of the immense scientific resources accumulated in that establishment during the last two centuries for the study of nature.

A VIENNA correspondent sends us the following data regarding the Agram earthquake:—The damp ejected matter of the mud-volcano at Resnica near Agram was found to contain no elementary sulphur nor sulphuretted hydrogen, but it contained sulphur metals decomposable by acids, and earthy carbonates, along with organic substances of a humus nature. The chief constituent of it is fine sand with water, and it comes from no great depth. The mud-volcano at Sevete, near Agram, also ejects (2 m. high) chiefly a clayey-sandy mud, which may be thrown up by movements of the ground water. The Gratz geologist, Peters (writing in the *Tagespost*), characterises the Agram earthquake of November 9 to 14 as one of the most normal which could be observed in that region. The movement kept exactly the direction of south-south-west, and was thus precisely at right angles to the chief direction of the Eastern Alps. The entire breadth of the territory affected appears to be indicated by the towns of Klagenfurt (Carinthia) and Szegedin (Hungary). Since the formation of the Alps, and so through a long series of geological periods, all subterranean movements in this region of Central Europe have been in this one direction (as Süss first showed). For some months past movements have been perceived to be in progress in various localities. That Agram should be affected as it has been is explained by an inspection of the geological map. Not very far north from that town rises a remarkable block of greenstone surrounded by chlorite schist, limestone and other layers. A not very broad band of recent Tertiary deposits separates the low ground from that mountain block, which thus forms a comparatively fixed point in the system. Every movement coming from south-south-west propagated by these strata must impinge horizontally on the greenstone block, and cause a greater or less curvature of the strata, which manifests itself most where the lower ground remains free from Tertiary deposits. Unfortunately for Agram the strongest movement was directed precisely against that mountain block, and so upon the town before it. The whole phenomenon has nothing to do with volcanic processes. The repetition of the shocks is easily explained by the reaction from curvature of the strata not occurring all at once. In opposition to Peters, the astronomer and meteorologist, Rudolph Falb of Gratz, holds the Agram earthquake to be volcanic, and connected with the strong attraction of subterranean lava by the moon. They seem to have continued at more or less frequent intervals during the past week.

IN several parts of the Tyrol (Hall, Thaur, Rum, Innsbruck) an earthquake-shock was experienced on the 14th inst. about 9.15 a.m., and on the same day there was a considerable shock (lasting 20 sec.) in Bavaria, at Partenkirchen and Mittenwald about 8 p.m. Dr. Franz Woehner has been delegated by the Vienna Academy to Croatia to report on the phenomena.

A CYCLONE accompanied by earthquake shocks is reported to have occurred at Sitka in Alaska on October 25, causing much devastation.

JUST after the death of its founder, Dr. Broca, the well-known *Revue d'Anthropologie* entered on its tenth year. His successor in the direction of the *Revue*, Dr. Topinard, issues a prospectus intimating that it will be continued with renewed energy on the lines laid down by its founder. The *Revue* embraces all the varied departments of anthropology, and its editor has the collaboration of the most eminent workers in the varied departments in France. Broca left a great number of anthropological papers in various stages of completeness, and these are to be published in successive numbers of the *Revue*, which deserves every encouragement.

THE laboratory of M. Lacazes Duthiers at the Sorbonne has been opened this year again for experiments in zoology. In the summer it will be transferred to the coast station in Britanny.

THE Paris Museum of Natural History being situated in a somewhat out-of-way place, is rather deserted by the students, and great efforts are made to render the course of lectures which are delivered there unusually attractive. M. Fremy, Lecturer on Chemistry, will speak on the great discoveries in chemistry made almost simultaneously in Paris and in London about a century ago, and will perform all the original experiments, some of them with the very instruments which were used by the discoverers.

A VERY interesting acquisition has just been made by the botanical department of the British Museum. In 1783-4 John Millar made a series of water-colour drawings for the Earl of Bute, showing the "leaves, stalks, and ramifications of plants, for the purpose of ascertaining their several species." They are bound in five volumes, with an elaborately flourished title page, and fill 928 octavo pages. The museum has purchased the drawings.

THE seismograph on Mount Vesuvius is said to indicate great subterranean dynamism. Streams of lava continue to flow down the north-west side of the cone, and are increasing both in volume and number. "The Vesuvian eruption," the *Times* correspondent states, "has entered on a phase of greatly increased activity. The news reached us on Saturday, but, as it appeared only in those papers which are directly interested in the Funicular